LATE CAMBRIAN TRILOBITES FROM THE NAJERILLA FORMATION, NORTH-EASTERN SPAIN

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ABSTRACT. Six late Cambrian trilobite taxa are described from the Najerilla Formation of the Mansilla district, Sierra de la Demanda, Logroño Province, northern Spain. *Maladioidella colcheni* sp. nov., *Langyashania felixi* sp. nov., an undetermined aphelaspidine genus and species, and an undetermined genus and species probably referable to Leiostegiidae, constitute the fauna of the basal member of the Najerilla Formation; and a younger assemblage comprising an undetermined solenopleuracean genus and species resembling *Lajishanaspis* Chu, 1979, and a pagodiine which may represent *Pagodia* (*Wittekindtia*) occurs at the top of member 2 of this formation. Although the available material is inadequate for the confident determination and description of all but two of the six taxa, it is important to document these assemblages because they belong to a late Cambrian biofacies from which trilobites have not been described or illustrated previously in the Mediterranean region. Earlier determinations given for some of these trilobites are unsatisfactory and biochronologically misleading. This Mediterranean biofacies has little in common with the well-known Acado-Baltic biofacies of northern Europe, but may have greater relationship with contemporaneous assemblages in central Asia and northern China.

RESUMEN. Se estudian varias sucesiones estratigráficas en los alrededores de Mansilla (Logroño) y se define formalmente la Formación Najerilla (Cámbrico superior—¿Tremadociense?). De esta formación se describen seis taxones de Trilobites, cuya conservación y el número de ejemplares recolectado, sólo permite determinar con precisión dos de ellas: *Maladioidella colcheni* sp. nov., *Langyashania felixi* sp. nov., un Aphelaspidino gen. et sp. indet., y otra especie y género indeterminado referible a un Leiostegido. En el techo del miembro 2, aparece un Solenopleuráceo gen. et sp. indet. aff. *Lajishanaspis* y un Pagodiino que probablemente se trate de *Pagodia* (*Wittekindtia*). Estas asociaciones representan un importante documento para conocer las biofacies mediterráneas del Cámbrico superior, cuyos Trilobites no habían sido ilustrados ni descritos; consecuencia de lo cual, esta primera determinación no ha dado todo el rendimiento apetecido para algunos de los taxones estudiados, de modo que su biocronología no queda bien establecida del todo. Las biofacies mediterráneas tienen poco en común con las mejor conocidas biofacies acadobálticas del norte, pero sí tienen una más estrecha relación con las asociaciones que coexisten en Asia Central y norte de China.

THE trilobites described in this paper are from the Mansilla district along the southern margin of the Sierra de la Demanda, an upland region which straddles the Burgos-Logroño provincial boundaries in north-eastern Spain (text-fig. 1). The geology of this area has been described in detail by Colchen (1974). Essentially, the Sierra de la Demanda massif is composed of Precambrian, Cambrian, Ordovician, and Carboniferous rocks, which, although separated from the Iberian Mountain Ranges to the south-east by Mesozoic cover, must represent a prolongation of the western Asturian-Leonese Zone as defined by Lotze (1945).

The existence of Cambrian rocks in the Sierra de la Demanda was first recognized by Schriel (1930) who quoted the occurrence of inarticulate brachiopods, and correlated the lithostratigraphic sequence with the Lingula Flags of Wales. Sos (1936) and Olagüe (1936) documented further brachiopod discoveries, and these were restudied by Hernández-Sampelayo (1942, 1949, 1950), who also reported the first trilobites, referred to *Olenellus*, and trace fossils, referred to *Cruziana*. Subsequently, middle Cambrian trilobites from the Mansilla district have been described and/or recorded by Sdzuy (1958) and Josopait and Schmitz (1971); late Cambrian brachiopods have been described by Colchen and Havliček (1968); and the problematical echinoderm *Oryctoconus* has

been described by Colchen and Ubaghs (1969). Colchen (1967, 1974) has also reported the occurrence of late Cambrian trilobites and early Ordovician articulate brachiopods, as yet undescribed. Seilacher (1970) has described *Cruziana barbata* from the early Cambrian part of the sequence below the Bunte Jalón-Schichten. Useful summaries of previous biostratigraphic work in the Sierra de la Demanda have been published by Colchen (1974) and Schmitz and Walter (1974). The material described herein is from sections originally investigated by Colchen (1964, 1967, 1974) and briefly also described by Calatayud, Garcia-Ruiz, and Pérez-Lorente (1980), and was mainly found by Liñán and Palacios during the course of re-mapping the Mansilla district (Palacios 1979). The material is housed in the collections of the Department of Palaeontology, University of Zaragoza.
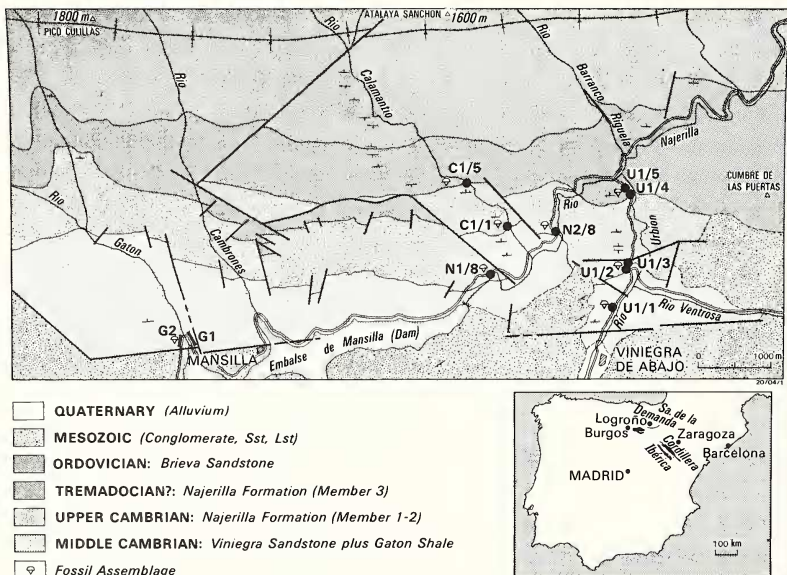
TEXT-FIG. 1. Geological map of the Mansilla district, Logroño Province, showing locations of collecting sites.

Although poorly preserved, this material is important. It is the first Spanish late Cambrian trilobite fauna to be described, and also represents the first documentation of the late Cambrian trilobite faunas of the Mediterranean region. The relationships of our faunas have considerable significance for the study of late Cambrian biogeography. Interestingly, they have little in common with the well-known Acado-Baltic late Cambrian faunas of northern Europe, but, as suggested by Colchen's original generic determinations of *Chuangia* and *Prochuangia*, there is close relationship with the faunas of central and eastern Asia.

In this paper, Liñán and Palacios were responsible for collecting the material and the introductory and stratigraphic passages; and Shergold is responsible for the sections on the age and relationships of the fauna and its systematic description.

STRATIGRAPHY

Stratigraphic summary

Following the recognition of Cambrian rocks in the Sierra de la Demanda by Schriel (1930), the lithostratigraphy has been developed by Lotze (1958, 1961, 1966) and Josopait and Schmitz (1971). Most of the terminology used herein, however, is based on the International Stratigraphic Guide (Hedberg 1976) (text-fig. 2). Brief notes are given for the stratigraphic units of the Mansilla district shown in text-fig. 3 to place the faunas of the Najerilla Formation in stratigraphic context and to document the presently known biochronology. Although quite heavily faulted and folded, the sequence in the Mansilla district is thought to be complete.

Urbión Dolomite (Josopait and Schmitz 1971). This formation comprises some 70 m of light-brown dolomite, massively bedded in its lower part, fining and becoming microlaminated upwards due to alternating micaceous and non-micaceous laminae. No fossils have been reported, but an early to middle Cambrian age can be inferred from the regional stratigraphic context and by correlation with the Ateca district to the south-east.

Mansilla Shale (Colchen 1974). This formation is composed of 39 m of green calcareous shale containing calcareous modules several centimetres in diameter. The upper part of the Mansilla Shale is sandy and less calcareous. The fauna contains trilobites, trilobitomorphs, brachiopods, echinoderms, and hyolithids, from which Josopait and Schmitz (1971, based on determinations by Sdzuy), Liñán (1979), and Palacios (in press) have reported *Badulesia tenera* (Hart), *Conocoryphe* (*Conocoryphe*) *heberti* Munier-Chalmas and Bergeron, *Conocoryphe* (*Parabailiella*) *languedocensis* Thoral, *Ctenocephalus* (*Hartella*) *antiquus* Thoral, *Ellipsocephalus*? sp. indet., *Paradoxides* (*Eccaparadoxides*) *mediterraneus*? Pompeckj, *Paradoxides* (*Eccaparadoxides*) *rouvillei* Miquel, *Paradoxides* sp., *Pardailhania hispida* (Thoral), *Pardailhania* cf. *hispanica* Sdzuy, *Peronopsis* sp., *Solenopleuropsis* cf. *ribeiroi* (de Verneuil and Barrande), *Solenopleuropsis* sp., *Riojaia perezi* Liñán, and *Decacystis* sp. This faunal assemblage indicates the presence of the *Badulesia*, *Pardailhania*, and *Solenopleuropsis* Substages of Sdzuy (1971, 1972) which are correlated with the *Paradoxides paradoxissimus* Stage of the Swedish Middle Cambrian.

SCHRIEL 1930		LOTZE 1961		COLCHEN 1974		JOSOPAIT– SCHMITZ 1971	CALATAYUD & others 1980		THIS PAPER		
ORD. Cb 3δ	ORD. U.C	Obere Demanda– Schichten	ORD	Grès de Brieva			ORD	Cuarcitas de Brieva	LOWER ORDOVICIAN	Brieva Quartzite	
UPPER CAMBRIAN	MIDDLE CAMBRIAN	Untere Demanda– Schichten	UPPER CAMBRIAN	Alternations de Najerilla			UPPER CAMBRIAN	Alternacias de Najerilla	UPPER CAMBRIAN	Mbr 3	Najerilla Formation
Cb 3β										Mbr 2	
										Mbr 1	
	LOWER CAMBRIAN	Mansilla– Schiefer	MIDDLE CAMBRIAN	Grès de Viniegra			MIDDLE CAMBRIAN	Areniscas de Viniegra	MIDDLE CAMBRIAN	UPPER	Viniegra Sandstone
		Obere Viniegra– Schichten								LOWER	
Cb 3α		Untere Viniegra– Schichten		Schistes de Gaton				Esquistos de Gatón		Gatón Shale	
Cb 2		Urbión– Schichten		Schistes Calcaires de Mansilla		Mansilla– Schiefer		Calcoequistos de Mansilla		Mansilla Shale	
		Ribota–Dolomit		Dolomite de Mansilla		Urbión Dolomit		Dolomia de Mansilla		Urbion Dolomite	
MIDDLE CAMBRIAN Cb 1δ		Bunte Jalón Schichten	LOWER CAMBRIAN	Schistes de Riocavado		Bunte Jalón– Schichten	LOWER CAMBRIAN	Esquistos de Riocavado	LOWER CAMBRIAN		
LOWER CAMBRIAN		Embider– Schichten		Quartzite de Punton				Cuarcitas de Puntón			
Cb 1β		Bambola-Quartzit		Conglomerat de Anguiano				Conglomerado de Anguiano			

TEXT-FIG. 2. Development of lithostratigraphic terminology in the Sierra de la Demanda.

Gaton Shale (Colchen 1974). This name is applied to the succeeding 200 m alternation of grey shale and sandstone. A massively bedded sandstone occurs at the base of the formation, but succeeding sandy layers are thinly bedded. Graded bedding, ripple marks, and ball and pillow structures characterize this unit, from which only ichnofossils are known: *Monocraterion* sp., *Planolites reticulatus* Osgood, and *Planolites* sp. A late *Paradoxides paradoxissimus* or post *P. paradoxissimus* middle Cambrian age is inferred by superposition.

Viniegra Sandstone (Colchen 1974). This formation includes 300 m of light-coloured sandstone, occurring in layers several metres thick, intercalated with thin grey shales and lenticular layers of bluish limestone. Ripple marks, flaser bedding and cross-lamination, slumping, and flute-casting have been observed. Brachiopods, trilobites, hyolithids and ichnofossils occur, the last including *Bergaueria* sp., *Cruziana* sp., *Diplichnites* sp., *Monocraterion* sp., *Planolites striatus* Hall, *Rusophycus didymus* Salter, and *Rusophycus* sp. Sdzuy (1958) described *Solenopleurina demanda* from a roadside exposure in this formation just to the north of the village of Viniegra de Abajo. A late middle Cambrian or even initial late Cambrian age is suggested by superposition.

Najerilla Formation (Colchen 1974, and see below). This is a thick unit, 700 m, of alternating sandstone and blue-grey decalcified shale. Fossiliferous layers occur near the base and top (text-figs. 3, 4). Brachiopods (Colchen and Havlíček 1968), echinoderms (Colchen and Ubaghs 1969), ichnofossils (Seilacher 1970), and trilobites (herein) have been described, and indicate that the base of the formation has a late Cambrian age, and the top is perhaps Tremadocian. The internal stratigraphy of this unit is described more fully below.

Brieva Sandstone (Colchen 1974). The Cambrian–Tremadoc sequence in the Mansilla district is capped by thick-bedded greyish quartz sandstone with interbedded shale and rare lenticular limestone, in excess of 440 m thick. An early Ordovician age is contemplated on the basis of trace fossils and brachiopods (see Colchen 1974).

The Najerilla Formation

The Najerilla Formation is based on the informal term Najerilla Alternations (Colchen 1974). 'Lower Beds of la Demanda' (Lotze 1961) is an earlier synonym (text-fig. 2). The Najerilla Formation is characterized by an alternation of sandstone and blue-grey shale, the latter containing intercalated lenticular limestone layers. It is distributed over some 500 km², occupying nearly all of the central part of the Sierra de la Demanda. The formation lies between massive sandstones or quartzites at the top of the Viniegra Sandstone and base of the Brieva Sandstone (text-fig. 3). The type section of the Najerilla Formation is located on the western bank of the river Calamantío. A supplementary (paratype) section is located along the valley of the river Urbión, by the side of the road which runs from Viniegra de Abajo to La Venta de Viniegra. At the type section, the formation strikes east–west, and beds dip to the north at 30–65°. Accurate assessments of thickness are complicated by the presence of several small-scale faults and folds. Nevertheless, three members, aggregating an estimated 660 m, can be recognized on the river Calamantío section.

Member 1 comprises alternating grey-brown shale and red calcareous sandstone, the latter predominating towards the base of the member. Sedimentary structures include current and wave ripples and slumping. The thickness is estimated at 85 m. Member 2 is recognized by the disappearance of calcareous sandstone and the introduction of blue-grey shale containing abundant organic matter. Some of the intercalated sandstones have thicknesses of several metres. Calcareous layers and nodules reappear in the upper part of this member, which has an estimated thickness of 290 m. Member 3 commences with a thick quartzite layer, about 100 m thick, and is followed by an alternation of blue-grey shale and quartz-feldspar sandstone, totalling some 270 m.

Along the river Urbión, there is also a general east–west strike and northerly dip. The same three members can be recognized, but member 1 is thinner here, having an estimated thickness of only 65 m, and there are fewer bioturbated layers. In member 2, which is correspondingly thick at 350 m, the sandy intervals have thickened at the expense of the shales. Member 3 is now

200 m thick, and in it the thickness of the sandstone layers is reduced. More trilobites and brachiopods have been found on the Urbión section than on the type section.

FAUNA OF THE NAJERILLA FORMATION: AGE AND RELATIONSHIPS

Six trilobite taxa, probably representing four superfamilies, are segregated into two regionally discrete faunal horizons, as noted earlier by Colchen (1967, 1968, 1974). His horizons F1–3 are equivalent to our collected localities U1/2–3 and N1/4–8 on the Rio Urbión and Rio Najerilla sections respectively, and his F4 is equivalent to our U1/4 and C1/5, the latter on the Rio Calamantío section.

So far, the earlier fauna, from U1/2–3, N1/4–8, comprises four taxa, as follows: Aphelaspidine genus et species undetermined; leiostegiid? genus et species undetermined; *Maladioidella colcheni* sp. nov. (Pterocephaliidae); *Langyashania felixi* sp. nov. (Shirakiellidae). The younger fauna, from U1/4 and C1/5, has yielded only two taxa: pagodiine genus et species undetermined (possibly *Pagodia* (*Wittekindtia*) sp. undet.); solenopleuracean? genus et species undetermined aff. *Lajishanaspis* sp. undet. The two faunas are separated by a 400 m thick alternation of siltstone and quartzite layers (text-fig. 3) in which only brachiopods (Colchen and Havliček 1968) and ichnofossils, *Cruziana*, *Rusophycus*, and *Planolites* spp. have been found.

The taxonomic philosophy employed here is a compromise between open nomenclature determinations and the creation of new taxa. Taxa have been left under open nomenclature where they are either inadequately preserved (solenopleuracean?), or numerically deficient (pagodiine, leiostegiid?, aphelaspidine). *Langyashania felixi* and *Maladioidella colcheni*, are sufficiently abundant in our collections, that they can be formally named as new taxa.

Colchen (1967, 1974) has referred previously to *Langyashania* under the name *Agraulos longicephalus* (Hicks), and to the pagodiine as *Chuangia* (of the *Ch. batia* (Walcott) group). The description of cranidia referred to *Prochuangia* (Colchen 1967, p. 1688) fits the genus *Maladioidella* of this account. Pygidia as described by Colchen (loc. cit., with a pair of marginal spines) have not been discovered in our collections.

Material recently collected by Palacios (1979) and Liñán is from thin (up to 25 cm thick) decalcified layers and laminae within the lowest siltstone unit of the Najerilla Formation (text-fig. 3); and from similar layers among more indurated siltstone containing decalcified nodules and lenses in the uppermost siltstone unit of this formation. Much of the material is poorly preserved and represented as fragile ferruginized moulds. Other material, occurring as scattered debris in compact micaceous siltstone is more robust, but not much better preserved. All material has been deformed to some extent: it has been flattened as well as sagittally and transversely compressed. Accordingly, foreshortened and elongated morphs of the same taxon, which may look quite different, have been recognized within material assigned to the aphelaspidine, the leiostegiid?, *Maladioidella* and *Langyashania*.

The late Cambrian faunal stratigraphy of the Mediterranean region as a whole, which extends at least from Spain to Turkey, is very poorly known. In this province, only brachiopods and ichnofossils have been described from upper Cambrian rocks. Although trilobites other than those described here have been noted, particularly from elsewhere in Spain (see Sdzuy 1972 for summary; Josopait 1972; Wolf 1980*a*) and Turkey (Haude 1972), they remain undescribed. There is therefore no biostratigraphic context in which to place the newly described faunas. Since they cannot be related to antecedent or descendant assemblages, there is no phylogenetic continuity, and biofacies relationships cannot satisfactorily be evaluated. Agnostid trilobites and wide-ranging polymeroids like *Irvingella* have not been described from the Mediterranean late Cambrian, with the result that an accurate dating for the faunas from the Sierra de la Demanda is also not yet possible. The quest for conodonts, which are as important as trilobites for correlation in the late Cambrian and Tremadocian, has been delayed, particularly in Spain, by the nature of the rock sequences — silts, sands, and quartzites. Microflora has been obtained from Cambrian–Ordovician transition beds in the Ateca–Daroca area, some 130 km to the south-east of the Sierra de la Demanda
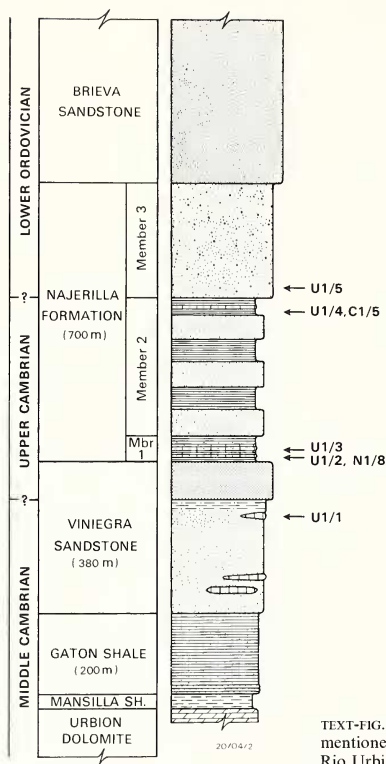
TEXT-FIG. 3. Stratigraphic relationship of samples mentioned in this paper. The scale is based on the Río Urbión section.

(Wolf 1980b), and it may eventually prove possible to use acritarchs to support macrofaunal correlations.

Taxonomic difficulties lead directly to other problems concerning the age and relationships of the two Sierra de la Demanda assemblages, particularly the earlier one. In the stratigraphic summary we have attempted to summarize the known Cambrian biostratigraphy of the Mansilla district based on information given in Lotze (1958, 1966), Lotze and Sdzuy (1958, 1972), Colchen (1964, 1967, 1968, 1974), Colchen and Havlíček (1968), Colchen and Ubaghs (1969), Seilacher (1970), and Josopait and Schmitz (1971). While the middle Cambrian assemblages are well known, and can be fairly readily related to the Mediterranean middle Cambrian biofacies previously described from Spain by Sdzuy (1968, 1971, 1972), only inferences can be made at this stage regarding the correlation of our late Cambrian assemblages. Contemporaneous rock sequences are known in the Ateca district, and in these the middle Cambrian faunas can be confidently recognized (Josopait and Schmitz 1971). It is more difficult to recognize the late Cambrian assemblages: the pagodiine

from our younger assemblage may correlate with the *Tinaspis* (Sdzuy *in* Josopait 1972; = *Pagodia* (*Wittekindtia*) *in* Wolf 1980*a*) recorded from the Valconchán Formation; and, from the earlier assemblage, our *Maladioidella* may represent Sdzuy's (op. cit.) *Taenicephalus?* sp., and our apelaspidine may be his *Taenora?* sp. (Shergold, in Sdzuy and Shergold, in prep.). Whereas these faunas are separated by some 400 m of strata in the Sierra de la Demanda, in the Ateca district they are in juxtaposition (see Josopait 1972, fig. 3).

1. The earlier late Cambrian fauna: this fauna cannot be placed accurately biochronologically for the above-stated reasons. Its co-occurrence with the articulate brachiopod *Billingsella* cf. *linguaeformis* Nikitin (see Colchen and Havliček 1968) suggests a late Dresbachian or younger age on the North American late Cambrian biochronological scale. *Maladioidella* ranges throughout the later two-thirds of Cambrian time, being first recorded apparently post-dating the recurrence of *Irvingella* in the *Eochuangia* Zone (late Changshanian) of South Korea, the *Wentsuia iota/Rhaptagnostus apsis* Assemblage-zone of northern Australia, and *Cedarellus felix* Zone of the northern Siberian Platform. It is last reported in the early Payntonian of northern Australia. *Langyashania* occurs in the middle part of the Langyashan Formation in Anhui Province, eastern China, where it is associated with *Rhaptagnostus* and *Prochuangia* species *inter alia*. Its range is not known, but if the Korean species *Megagraulos breviscapus* can be referred to it, then in South Korea at least it also occurs in the *Eochuangia* Zone (late Changshanian). The association of *Maladioidella*, *Langyashania*, and the apelaspidine which resembles forms from the *Irvingella* Zone of central Kazakhstan, tends to suggest an early Franconian (*Elvinia/Conaspis* Zones equivalents), rather than a late Franconian or Trempealeauan age on the North American late Cambrian biochronological scale.

No elements of the Acado-Baltic biogeographic province can be confidently recognized in the Mansilla faunas. If anything, the trilobites, like the billingsellid brachiopod, demonstrate greater relationships with some elements from the faunas of central Kazakhstan described by Ivshin (1956, 1962), and with eastern China (Lu and Zhu 1980). The apelaspidine appears more similar to forms actually described as *Apelaspis* by Ivshin (1956; *in* Nikitin 1956) from the Kujanda Yarus (late Dresbachian to early Franconian) than to late Dresbachian faunas described by either Palmer (1954, 1960, 1962, 1965) or Rasetti (1965) from North America; *Maladioidella*, originally described from north-eastern China by Endo, has a wide peri-Gondwanaland distribution from Turkey to northern Australia (Shergold and Sdzuy, in prep.); the shirakiellid *Langyashania* is known from eastern China and Korea; and the undetermined leiostegiid? may also relate to similar morphologies found in Kazakhstan (*Tatulaspis*) and the Sayan–Altai Basin of southern Siberia (e.g. *Chuangiopsis?*). Hence, although Colchen's (1964, 1967) determinations of Asian trilobite genera in the Sierra de la Demanda are not entirely correct, the early Franconian Mediterranean biofacies may well have had a Tethyan distribution similar to that of the early Tremadocian.

2. The younger late Cambrian fauna: different kinds of problems occur in assessing the relationships of this younger assemblage because it cannot be determined with confidence. The cranidium of the pagodiine could represent more than one late Cambrian genus (e.g. *Pagodia* (*Pagodia*), *Pagodia* (*Oreadella*), *Eochuangia*), or more than one early Ordovician taxon (*Pagodia* (*Wittekindia*), *Szechuanella*). However, in the Sierra de la Demanda, this pagodiine is found in association with questionable echinodermal debris described by Colchen and Ubaghs (1969) as *Oryctoconus lobatus*. Such material occurs elsewhere in northern Spain, notably in the Valconchán Formation of the Ateca–Daroca region (Wolf 1980*a*), where it co-occurs with a pagodiine which is indistinguishable from *Pagodia* (*Wittekindtia*), a Tremadocian taxon dated by conodonts originally described from Afghanistan (Wolfart 1970). Thus, the pagodiine cranidium from the Sierra de la Demanda may belong to *Wittekindtia*. In the Ateca district, the Valconchán Formation was deposited close to the transition from late Cambrian to early Ordovician time (Wolf 1980*a*, 1980*b*; Sdzuy and Shergold, in prep.). The dating depends largely on the age of the overlying biotas of the Borrachón Formation. Wolf (1980*b*) found that the acritarch assemblages of the Borrachón differed from those of the Valconchán Formation. Similarly, the trilobites he listed (1980*a*) are different, those from the Borrachón Formation constituting an early Tremadocian olenid/asaphid

biofacies similar to that already known in central Mexico (Robison and Pantoja–Alor 1968), Argentina (Harrington and Leanza 1957), and Bolivia (Pribyl and Vaňek 1980), which may represent the shelly equivalents of the Acado–Baltic olenid/graptolite facies. This American biofacies is rather distinct from that commonly encountered elsewhere in southern and central Europe (southern France, Bavaria, Bohemia), which is characterized by the frequent association of such forms as *Niobella*, *Proteuloma*, *Onchonotellus*, and *Macropyge*, and can be traced into central Turkey, southern Kazakhstan, Afghanistan, southern Siberia, and northern China according to Shergold and Sdzuy (in prep.).

The age of *Pagodia* (*Wittekindtia*) in Spain therefore poses a chronological problem: it has a Tremadocian age based on conodonts in Afghanistan where a Eurasian biofacies prevails, and yet it predates an Acado–Baltic cum South American biofacies demonstrably of initial Tremadocian age, also on the basis of conodonts. The dilemma can be solved if it is assumed that *P.* (*Wittekindtia*) initially occurs in the late Cambrian. It seems that a terminal Cambrian age must be accepted in the Ateca district. By association with *Oryctoconus*, a similar age is correlated to the Sierra de la Demanda. Unfortunately, the pygidium of *Wittekindtia*, which is characterized by a pair of anterolateral ventrally directed articulating spines, and which would settle the issue of correlation, has not been confirmed there. Support for a probably terminal Cambrian age for the pagodiine in the Sierra de la Demanda comes from eastern China where sequences containing *Pagodia* (*Pagodia*) *major* Lu and Zhu (1980) and saukiid trilobites overlie the Langyashan Formation whose middle part contains *Langyashania*.

SYSTEMATIC DESCRIPTIONS

The terminology used in the ensuing taxonomic descriptions and discussions is based on that defined by Harrington, Moore and Stubblefield (*in* Moore 1959, pp. 117–126), with additions and modifications as suggested by Öpik (1961, 1963, 1967) and Shergold (1972, 1975). The eye indices are defined by Struve (1958).

Symbols used for measured parameters herein are:

Lc	maximum cranidial length (sag.)
Lb	length (sag.) of cranidial or pygidial borders
G	maximum glabellar length (sag.)
Gn	maximum glabellar length plus occipital ring (sag.)
A	maximum length (exsag.) of palpebral lobe
Lp_1	maximum pygidial length (sag.) including the articulating half-ring
Lp_2	maximum pygidial length (sag.) excluding the articulating half-ring
Wp	maximum pygidial width (tr.)
A : G	large eye index
A : Gn	small eye index

Superfamily OLENACEA Burmeister, 1843
Family PTEROCEPHALIIDAE Kobayashi, 1935
Subfamily APHELASPIDINAE Palmer, 1960

Aphelaspidine genus et species undetermined

Plate 12, figs. 8–11

Material. Five cranidia and cranidial fragments (N1/8/4, N1/1/8/5a, N1/8/7–8, U1/2/15) measuring between 4·5 and 9·0 mm (four specimens) are matched with two pygidia (U1/2/95–96) with lengths (Lp_1) of 6·0 and 7·5 mm respectively.

Occurrence. Member 1 of the Najerilla Formation; Rio Urbión section, horizons U1/2, U1/3; Rio Najerilla section, horizons N1/8.

Description. The cranidium is elongate (sag.), flat in anterior profile, and with low to moderate convexity

(sag.) in lateral aspect. The glabella is long (sag.), 55–61% of the cranidial length (sag.) (G : Lc) for three measured specimens, 69–72% if the occipital ring is included (Gn : Lc); anteriorly truncate; anteriorly tapering; moderately convex (sag.) in lateral profile; and with a hint of preoccipital glabellar furrows. The occipital ring is as wide as the preoccipital glabellar width (tr.), and also has low convexity (laterally). The palpebral lobes attain 44–50% of the glabellar length (G), and have mid-points opposite or just behind the middle of the glabella (G). The width (tr.) of the palpebral areas is about 0·3 that of the glabella opposite the mid-points of the palpebral lobes. Ocular ridges are effaced. The preocular sections of the facial sutures enclose a relatively long (sag.) preglabellar area, up to one-third the cranidial length (sag.), which comprises a gently convex (sag.) preglabellar field, a sharp and narrow anterior cranidial marginal furrow, and a narrow (sag.) upturned anterior cranidial border, 10–12% of the cranidial length (Lc). The postocular sections of the facial suture enclose blade-like posterolateral limbs.

Two pygidia are associated with the cranidial fragments, and because they resemble those associated with aphelaspidine cranidia in Kazakhstan, are referred to the same species. These pygidia are subtrapezoidal, with lengths (Lp_1) about 50% of the maximum width (Wp), and have steeply inclined articulating facets which emphasize their shape. The axis, with three segments and a terminal piece, is long (sag.), reaching to the posterior pygidial margin. There are two pleural segments defined by pleural furrows. The anteriormost pleural furrows extend almost to the anterolateral margin, but end blindly a short distance in front of the articulating facets. The second pair of pleural furrows merge distally into the posterolateral marginal furrow which is a shallow flange limited in its extent between the end of the axis and the distal ends of the second pleural furrows. The pleural zone behind the second pleural segment slopes steeply into this marginal furrow and has a strongly triangular shape. The pygidial border is also restricted by the length of the axis and is defined only adjacent to the marginal furrow.

Discussion. Our material differs from the typical *Aphelaspis* Resser, 1935 in its palpebral morphology: its ocular ridges are not prominent, but its palpebral lobes are posteriorly situated. Among *Aphelaspis* species, only *A. haguei* (Hall and Whitfield) appears to have comparably situated palpebral lobes (see Palmer 1965, p. 59, pl. 9, figs. 19–26). Glabellar and preglabellar morphology resembles such species as *A. longispina* Palmer (1965, p. 60, pl. 9, figs. 13, 15–17).

Aphelaspidine undetermined has a simple reflected anterior cranidial border which distinguishes it from several pterocephaliine genera otherwise sharing cranidial resemblance, e.g. species of *Cernuolimbus* Palmer and *Listroia* Palmer (see Palmer 1960, 1962, 1965). The absence of a preglabellar boss precludes classification with forms such as *Kujandaspis* Ivshin or *Ketyna* Rozova. In *Amorphella* Rozova (see *A. modesta* Rozova, 1968, pl. 7, figs. 6–14) there is also a tendency to produce a preglabellar swelling, otherwise this genus is cranidially similar. *Lochmanaspis* Ivshin (1962, pl. 20, figs. 1–5) is essentially similar, but has a pitted anterior cranidial marginal furrow, more like that of *Lakella* Kobayashi (1962, p. 79). Some species of *Kaninia* Walcott and Resser are also cranidially similar judging from their original illustrations (see *K. lata* Walcott and Resser, 1924, pl. 1, fig. 22; *K. quadrata* Lazarenko, 1960—see Lazarenko and Nikiforov 1968, pl. 15, figs. 1–3) but the palpebral lobes appear to be situated further to the rear of the cranidium. Most closely related, however, appear to be species from Kazakhstan referred to *Aphelaspis* by Ivshin (1956), particularly *A. nobilis* Ivshin (1956, pl. 3, figs. 1–12, 13; pl. 4, figs. 16–17). The holotype cranidium of that species, however, has a mesially interrupted anterior cranidial marginal furrow, and more anteriorly situated palpebral lobes.

The associated pygidia very strongly resemble those from central Kazakhstan illustrated by Ivshin (1956, pl. 4, figs. 19–23) as *Aphelaspis* sp. There is also resemblance to others from Tennessee referred to *Dytremacephalus angulatus* by Rasetti (1965, pl. 21, figs. 6–8), but in those the marginal furrow merges with the first pleural furrows rather than the second. The pygidium assigned to *Kaninia quadrata* by Lazarenko (*in* Lazarenko and Nikiforov 1968, pl. 15, fig. 4) has a similar triangular shape, flat flange-like borders, and a posteriorly extended axis. That assigned to *Kaninia*? sp. 2 (Rozova 1968, pl. 9, fig. 16) has a shorter axis. Similarly the pygidium of *Amorphella modesta* Rozova (see Rozova 1968, pl. 7, fig. 14), although triangular and having flat borders, also has a short axis. The pygidium assigned to *Pesaia* by Walcott and Resser also has an appropriate shape, an axis extending to the posterior border, and comparable borders. In *P. exsculpta* (see Walcott and Resser 1924, pl. 2, figs. 18–19), the anterior and lateral pygidial margins are drawn into a

lateral point similar to that seen here on Pl. 11, fig. 10, but the borders are thicker, and together with the pleural exoskeletal surface, heavily striated with terrace lines.

<div align="center">Genus MALADIOIDELLA Endo, 1937</div>

Type species. *Maladioidella splendens* Endo (*in* Endo and Resser 1937, pp. 346–347, pl. 69, figs. 13–18), late Changshanian, Daizan Formation, Paichiashan Hill, Chinchiachengtzu, Liaoning, China; by original designation.

Other species. Other species of *Maladioidella* have been listed by Shergold (1975, p. 152; 1980, p. 51). To these should possibly be added *Saratogia latefrons* King (1937, pp. 10–12, pl. 2, fig. 3*a–c*), from north-central Iran. This species was nominated as the type of *Iranella* by Hupé (1953), but it has been regarded subsequently by Kobayashi (1967, p. 493) and Wolfart and Kürsten (1974, p. 218) as a species of *Maladioidella*. In addition, *Cedarellus felix* Lazarenko (1966, pp. 48–49, pl. 3, figs. 1–9), from the *Irvingella* Zone of Yakutia, may represent an *en grande tenue* species of *Maladioidella*; cranidia, which Lake (1931, p. 131, pl. 16, figs. 10–15) referred to *Conocephalina abdita* (Salter 1866) may represent a deformed species of *Maladioidella* occurring in Wales; and it may be possible to regard such taxa as *Elrathiella taira* Kobayashi (1962, p. 50, pl. 4, figs. 3–4) and *Megagraulos medius* Kobayashi (1962, p. 66, pl. 2, figs. 2–3) from the *Eochuangia* Zone of South Korea as a deformed effaced species of *Maladioidella*.

Discussion. The type material of *Maladioidella* has been rediagnosed, redescribed and reillustrated by Lu and Zhu (1980, pl. 2, figs. 5–7; pl. 3, figs. 1–2; pl. 4, fig. 1). If *Iranella* Hupé, 1953, and *Cedarellus* Lazarenko, 1966, are accepted as synonyms of *Maladioidella* then the concept of the genus must be expanded to include species, with both more strongly developed dorsal furrows and those in which they are largely effaced. Effacement apart, cranidia of all their genera are morphologically similar, *Maladioidella sensu* Endo (1937) and *Cedarellus* also have similar pygidia.

Maladioidella has been classified (Shergold 1975, 1980) within the Family Idahoiidae Lochman because the construction of the cranidium and librigena was considered more typical of Idahoiidae than Pterocephaliidae with which it was previously classified. Furthermore, the pygidium described by Shergold (1980) for *M. doylei* could not be accommodated in the latter. This pygidium is quite distinct from those assigned by Endo (1937) to *M. splendens* and by Lazarenko (1966) to *Cedarellus felix*, and in retrospect probably does not belong to *Maladioidella*. Accordingly, reclassification with Aphelaspidinae (Pterocephaliidae, Olenacea) must be considered from a number of lines of evidence. (1) There is some resemblance between cranidia of *Maladioidella* and those of some short-eyed aphelaspidine pterocephaliids such as *Litocephalus* Resser, *Olenaspella* Wilson, *Eugonocare* Whitehouse, *Aphelaspidella* Rasetti, some species of *Aphelaspis*, and pterocephaliines like *Cernuolimbus* Palmer. Attention is drawn particularly to such species as *Aphelaspidella macropyge* Rasetti (1965, p. 96, pl. 11, figs. 1, 2, 7, 8), *Aphelaspis camiro* (Walcott) *sensu* Rasetti (1965, p. 83, pl. 12, figs. 1–17), *A. bridgei* Rasetti (1965, p. 77, pl. 13, figs. 1–7), and *A. laxa* Resser *sensu* Rasetti (1965, p. 80, pl. 13, figs. 8–15). The more effaced forms of *Maladioidella* quite closely resemble the aphelaspidine *Taenora*, as previously noted by Palmer (1960, p. 80). (2) The hypostoma

<div align="center">EXPLANATION OF PLATE 11</div>

Figs. 1–13. *Maladioidella colcheni* sp. nov. 1, U1/2/62, internal mould of laterally compressed cranidium, length 25 mm; ×2. 2, U1/2/12b, lateral view of internal cranidial mould; ×2. 3, U1/2/93, internal mould of obliquely distorted cranidium, estimated length 8 mm; ×3·5. 4, U1/2/7, holotype, internal mould of cranidium; length 26·5 mm; ×1·5. 5, U1/2/55, internal mould of hypostoma; ×1·5. 6, U1/2/100B, internal mould of librigena, ×3, associated with undetermined aphelaspidine cranidium (U1/2/100A). 7, U1/2/8b, latex replica of cranidial mould, ×1·5. 8, U1/2/57, internal mould of cranidium slightly obliquely compressed; length 14 mm; ×3. 9, U1/2/11, internal mould of pygidium, estimated length (Lp₂) 6·5 mm; ×2·5. 10, U1/2/19, lateral view of pygidium, estimated length (Lp₂) 12·25 mm; ×1·5. 11, U1/2/19, as above, dorsal view, ×1·5. 12, U1/2/81, internal mould of pygidium, length (Lp₂) 7·5 mm; ×3·5. 13, U1/2/73, internal mould of pygidium, length (Lp₂), 9·5 mm; ×2·5.

PLATE 11
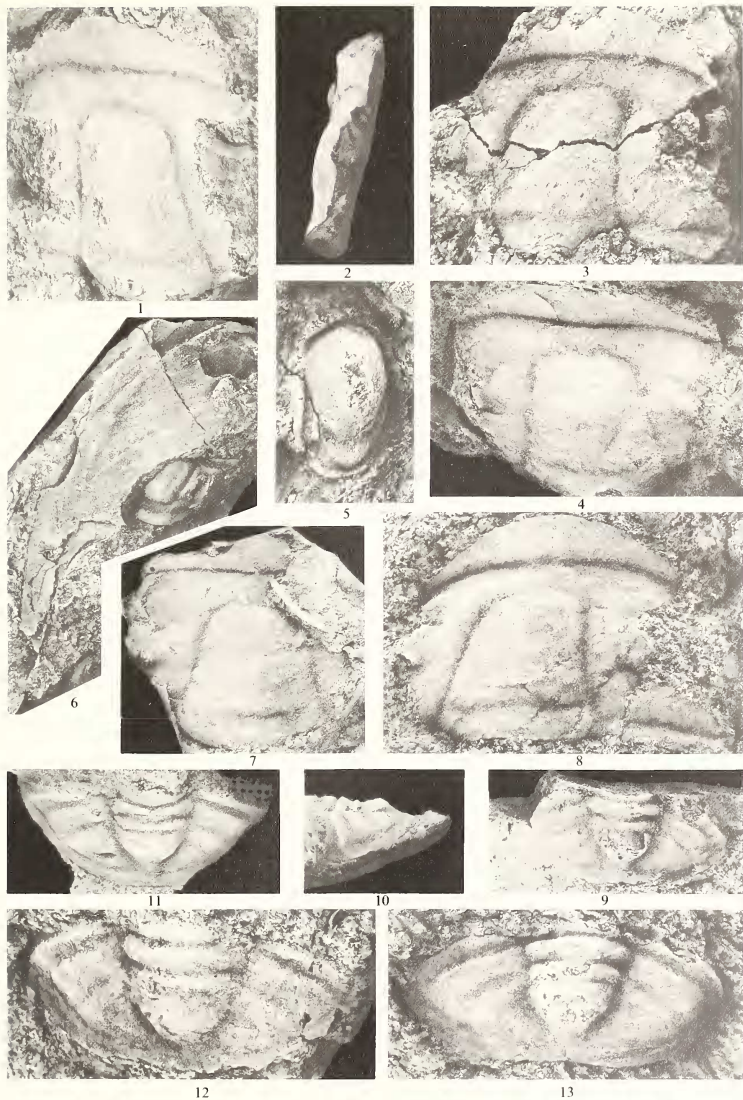
SHERGOLD, LIÑÁN and PALIACOS, Spanish Cambrian trilobites

illustrated here in association with *M. colcheni* very closely resembles those assigned by Rasetti to *A. camiro* (Walcott) (Rasetti 1965, pl. 12, figs. 11, 15), *A. rotundata* Rasetti (op. cit., pl. 14, fig. 4), and *A. tarda* Rasetti (op. cit., pl. 20, fig. 9). Palmer (1960, pl. 11, figs. 4, 8) has illustrated other similar hypostomata and suggested that they may belong to the pterocephaliine *Cernuolimbus* with which cranidial resemblance is noted above. (3) Pygidia assigned to *M. splendens* by Endo (1937) have a pterocephaliine shape, similar, but shorter to those of species of *Signocheilus* as illustrated by Palmer (1965). Pygidia assigned to *Cedarellus felix* Lazarenko also have this shape. Those associated with cranidia of *M. colcheni* figured here more closely resemble the specimen from Kazakhstan which Ivshin (1956) has placed in species of *Aphelaspis*, particularly *A. nobilis* Ivshin (1956, pl. 3, fig. 13), but cranidia of *A. nobilis* (loc cit., figs. 1–12) have a tendency to form a preglabellar boss which distinguishes them immediately. An overall balance of characteristics, therefore, seems to favour classification with Pterocephaliidae rather than Idahoiidae, and this classification is adopted here.

Maladioidella colcheni sp. nov.

Plate 11, figs. 1–13

1967   *Prochuangia* (*pars*, cranidium only); Colchen 1967, p. 1688 (listed).
1974   *Prochuangia* (*pars*, cranidium only); Colchen 1974, p. 180 (listed).

Name. This species is named for Dr. Michel Colchen who originally found late Cambrian trilobites in the Mansilla district, Sierra de la Demanda.

Types. Holotype, cranidium, University of Zaragoza Palaeontological Collections U1/2/7; paratype cranidia, same collection U1/2/8, 12, 15b, 19, 57, 62, 83, 93, 98; paratype librigenae, U1/2/5, 14, 17, 55, 73, 90, 92; paratype hypostomata, N1/8/5d, N1/8/1b, U1/2/100b; paratype pygidia, N1/8/9, 12, U1/2/11, 19, 20, 21, 50, 61, 70, 71, 73, 75, 76, 81, 82, 88, 90, 97, 100c.

Material. This is the most abundant taxon in the present collections. There are ten measurable cranidia and fragments of many others, twenty-one pygidia, eleven librigenal fragments, and three appropriately sized hypostomata may also belong to this taxon. Cranidia are rather large but generally incomplete; measurable specimens have estimated lengths (Lc) between 5·5 and 26·5 mm, and associated pygidia measure between 4·0 and 14·0mm.

Occurrence. Rio Urbión section, U1/2, U1/3; Rio Najerilla section, N1/8; member 1 of the Najerilla Formation.

Diagnosis. A semi-effaced species of *Maladioidella* with the following cranidial characteristics: truncato-conical glabella with effaced furrows; small palpebral lobes, relatively wide spaced, situated a short distance in advance of the middle of the glabella (G); a relatively short (sag.) preglabellar area, about half the glabellar length (G).

Description. The cranidium of *Maladioidella colcheni* sp. nov. has a subrectangular glabella which tapers gently forwards, has effaced furrows, and is sometimes laterally constricted and anteriorly truncate. For ten measured specimens, the glabella (G) varies between 50 and 80% of the cranidial length (sag.), 64 and 73% if the occipital ring is included (Gn : Lc). The glabella has a very low lateral profile. The occipital furrow generally reaches the axial furrows abaxially, and defines an occipital ring which is transversely slightly wider than the preoccipital glabellar width. *M. colcheni* has small (exsag.) palpebral lobes whose mid-points lie slightly in advance of the middle of the glabella (G.). They are quite wide-spaced: the palpebral areas are a little over half the glabellar width (tr.) at the level of the middle of the palpebral lobes. Faint, gently oblique, duplicated ocular ridges are seen on some specimens. The preocular sections of the facial suture diverge widely and define a wide (tr.) preglabellar area, one-half to one-third as long (sag.) as wide (tr.). The preglabellar field and anterior cranidial border are of approximately equal width (sag.), but the former slopes gently forwards, and the latter is often flat or gently reflected. The border occupies 16–21% of the cranidial length (sag.). The anterior cranidial marginal furrow is sinuous to varying degrees depending largely on deformation, and is not pitted. The postocular sections of the facial suture are also widely divergent, and these enclose transversely extensive posterolateral limbs which are broadly triangular. They bear posterior marginal furrows which terminate at the distal extremities of the posterolateral limbs, and do not continue on to the librigenae. The assigned

librigenae are broad and flat, with an anterior prong and a short genal spine. The lateral marginal furrows are shallow depressions, but the posterior ones are effaced completely.

Three hypostomata may also belong to *M. colcheni*: the largest has a length (sag.) of 9·5 mm. These hypostomata are long (sag.) and relatively narrow (tr.) (the width of two measurable specimens is between 66 and 68% of the length), and they have narrow lateral and posterior borders. The anterior border is an upturned edge, whereas the remaining borders are distinctly thickened, the lateral ones almost parallel-sided, and the posterior one truncate. The median body is long (sag.) and ovoid, highly but narrowly convex (tr.), and possesses a well-defined posterior lobe. The maculae are small and inconspicuous.

The pygidium, assigned on both abundance and association, is subtrapezoidal, but is generally deformed. The axis has three well-defined segments and a terminal piece, and a short (sag.) post-axial ridge carries its course to the posterior marginal furrow. There are three complementary pleural segments, each marked by wide (exsag.) pleural furrows. The border is evenly narrow, and the marginal furrow represents the break in convexity between the pleural zone and border except anterolaterally where it merges with the first pleural furrow distally.

Superfamily SOLENOPLEURACEA Angelin, 1854
Family INCERTAE SEDIS
Solenopleuracean? genus et species undetermined
aff. *Lajishanaspis* Chu, 1979 sp. undet.

Plate 12, figs. 12–13

Material. A single cranidial fragment (U1/4/1), with glabellar length (G) of 3·75 mm.

Occurrence. Member 2 of the Najerilla Formation; Rio Urbión section, horizon U1/4.

Discussion. It is not possible to accurately classify the cranidial fragment at our disposal since little is known of the palpebral lobes or preglabellar area. It has an ovoid, laterally expanded, convex (tr., sag.) glabella with three pairs of transverse gently curved furrows; a narrow (sag.) occipital ring; and vestiges perhaps of palpebral lobes which appear to lie close to the glabella. The preglabellar area may exclude a preglabellar field.

The glabellar shape is reminiscent of some olenaceans (olenids), solenopleuraceans (lonchocephalids, onchonotellids), and catillicephalaceans (catillicephalids). Catillicephalidae, as conceived by Rasetti (*in* Moore 1959), most typically seem to have a forwards expanding glabella extending to the anterior cranidial margin and excluding a preglabellar area. Öpik (1967) included *Onchonotellus* Lermontova, 1956 in this family, but this genus has a shorter (sag.), more ovoid glabella, and a distinct anterior cranidial border. Lu (*in* Lu *et al.* 1965) created the Family Onchonotellidae to accommodate this genus and classified it among Solenopleuracea, and this assignment is preferred here, thus preserving Rasetti's concept of Catillicephalidae. Generally in *Onchonotellus* the glabellar furrows are faint, but they are observed on some otherwise generically indistinguishable taxa, e.g. *Onchonotellus privus* Rozova (1968, pl. 1, figs. 1–9; Lazarenko 1966, pl. 8, figs. 1–3), and *O. trisulcatus* Ivshin (1962, pl. 7, figs. 13–15). Species of *Seletella* Ivshin, 1962 and *Seletoides* Ivshin, 1962 also have swollen glabellae, but these lack furrows and the frontal lobe is distinctly pointed. *Galeaspis* Ivshin, 1962 also lacks glabellar furrows, but is highly granulose. A virtually identical cranidial fragment described from the late Cambrian of Qinghai by Chu (*in* Chu, Lin and Zhang 1979, pp. 101–102, pl. 40, figs. 9–12) as *Lajishanaspis subsphaericusa* gen. et sp. nov., and assigned to the Family Catillicephalidae (Solenopleuracea). In our opinion this Chinese cranidium can be no more confidently determined than that figured under open nomenclature here.

Typically, lonchocephalids have an occipital spine, but some genera included in the Family Lonchocephalidae do not. The glabellar shape and segmentation of the Spanish cranidium resembles those specimens from Maryland which Rasetti (1961, pp. 117–118, pl. 24, figs. 23–25) described as *Quebecaspis conifrons* Rasetti, and similar ones from Alaska which Palmer (1968, p. 95, pl. 9, figs. 8–10) described as *Quebecaspis conifrons*? Rasetti. These forms have a late Dresbachian or early Franconian age in North America.

Some olenaceans also have a glabellar shape similar to the Spanish fragment, e.g. species of

Peltura and *Westergaardia* in the late Cambrian of Scandinavia (Henningsmoen 1957), and some species of *Bienvillia* from North and Central America (see *B. grandis* Robison and Pantoja-Alor, 1968, pl. 100, fig. 16). In general, these olenaceans can be distinguished by their small, anteriorly situated palpebral lobes. Although insufficient information is available, it would appear that the Spanish specimen has palpebral lobes situated at least opposite the glabellar mid-point, and perhaps even behind this.

On the balance of its characteristics, the present material appears to have most similarity with Solenopleuracea, but because it is not possible to classify it satisfactorily, we can only regard it as a queried and undetermined solenopleuracean with affinity with *Lajishanaspis* Chu.

<div align="center">

Superfamily LEIOSTEGIACEA Bradley, 1925
Family LEIOSTEGIIDAE Bradley, 1925
Subfamily PAGODIINAE Kobayashi, 1935
Pagodiine genus et species undetermined
aff. *Pagodia* (*Wittekindtia*)? Wolfart, 1970

Plate 12, figs. 14–15

</div>

1967   '*Chuangia*, en particulier au groupe *Chuangia batia* (Walcott)'; Colchen 1967, p. 1688 (listed).
1974   '*Chuangia*, en particulier au groupe de *Chuangia batia*'; Colchen 1974, p. 180 (listed).

Material. A single cranidium (C1/5/1), known from internal and external moulds, with length (Lc) of 8·5 mm; and a single pygidium (C1/5/2) of doubtful association, 6·0 mm long (Lp_2).

Occurrence. Member 2 of the Najerilla Formation, Rio Calamantio section, horizon C1/5.

Discussion. The inadequate nature of this material prevents a comprehensive description. The cranidium is slightly compressed sagittally, and the pygidium is vertically compressed.

The cranidium is characteristically pagodiine, having a glabella which extends to the anterior cranidial marginal furrow and an upturned cranidial border. The glabella (G), occupying some 76% of the cranidial length (sag.), tapers very gently forwards, is bluntly rounded anteriorly, and bears vestiges of at least two pairs of apparently transverse furrows. There is a faint lateral constriction at the level of the median furrows, and anterolaterally the axial furrows are bridged by a diverticulum which connects the anterolateral corners of the glabella to the preocular areas. Both features are seen in other pagodiines. The palpebral lobes, which are situated behind the mid-point of the glabella, are also similar to those seen in other pagodiines.

The associated pygidium has an entire rounded margin. The axis is composed of four segments and a terminal piece, but only a single pleural segment is visible. It appears to have a distinct marginal furrow and border, a feature not commonly found in Pagodiinae, and more typical of Leiostegiinae such as *Leiostegium* Raymond *sensu* Walcott (1925). The adventrally directed anterolateral articulating spines, which would permit classification with *Pagodia* (*Wittekindtia*) have not been observed.

Cranidially, this Spanish pagodiine could be referred to a number of genera. It is, however, insufficiently effaced for classification with *Chuangia* Walcott, the glabella is insufficiently conical for inclusion in *Lotosoides* Shergold, and the anterior border is upturned and not flat as in *Iranochuangia* Kobayashi. Accordingly, it could belong to *Prochuangia* Kobayashi, *Eochuangia* Kobayashi, *Szechuanella* Lu, or one of the subgenera of *Pagodia* Walcott (see Shergold 1980, p. 68, table 2 for listed pagodiine cranidial characteristics). More material is required to confirm the pygidial association.

The material is therefore insufficient to assign a genus with confidence. However, deductive rather than objective reasoning suggests the possibility of classification with *Pagodia* (*Wittekindtia*) Wolfart. Our material is associated with pelmatozoan debris which has been described as *Oryctoconus lobatus* by Colchen and Ubaghs (1969). Similar debris, also determined as *Oryctoconus* (e.g. Wolf 1980a), occurs to the south-east of the Sierra de la Demanda, between Ateca and Daroca in both the eastern and western Iberian Mountain Chains. In this area, *Pagodia* (*Wittekindtia*)

(= *Tinaspis*? of Josopait 1971) occurs with *Oryctoconus* close to the Cambrian–Tremadoc boundary at several localities in the Valconchán Formation (Wolf 1980*a*; Sdzuy and Shergold, in prep.). We acknowledge, however, that such material as has been referred to *Oryctoconus* may have a long stratigraphic range, and that the pagodiine we have described here may eventually prove to be other than *Wittekindtia*. For instance, material from eastern China, described as *Pagodia* (*Pagodia*) *major* by Lu and Zhu (1980, p. 18, pl. 5, figs. 10–12), apparently occupies a similar stratigraphic position with regards the occurrence of *Langyashania*. *P.* (*P.*) *major* has a similar cranidium to the Spanish *Pagodia* (*Wittekindtia*), but as in that species the possession of a pygidial articulating spine cannot be confirmed. Thus there is a possibility that the specimens from Mansilla could also represent *Pagodia* (*Pagodia*).

<div align="center">Leiostegiid genus et species undetermined</div>

<div align="center">Plate 12, figs. 4–7</div>

Material. This taxon is known only from four cranidial fragments (N1/8/12, U1/2/9, 27, 80), with estimated lengths (Lc) between 9·0 and 19·0 mm.

Occurrence. Member 1 of the Lower Najerilla Formation; Rio Urbión section, horizon, U1/2; Rio Najerilla section, horizon N1/8.

Description. This undetermined leiostegiid genus has an elongate cranidium with low convexity, both in anterior and lateral profiles. Characteristically, our material has a relatively long (sag.) (G : Lc 60–64%) anteriorly tapering, pear-shaped glabella which bears traces of three pairs of glabellar furrows. The preoccipital furrows are gently curved and posterosagittally directed; the median lateral ones are shorter (tr.), more gently curved; and the anterolateral ones are very short (tr.), and more or less transverse. The occipital furrow is curved anteriorly, reaches the axial furrows, and defines a crescentic occipital ring which has about the same transverse width as the preoccipital lobes. The palpebral lobes are inadequately known; they seem to be posteriorly sited, with their anterior tips opposite the middle or rear of the median lateral glabellar lobes, but the position of their posterior tips cannot be confirmed. They are connected by faint ocular ridges to the frontal glabellar lobe. The intraocular width (tr.) is appreciable, the width (tr.) of each palpebral area being at least 50% of the preoccipital glabellar width. The preocular areas are gently convex (exsag.); they curve around the anterolateral corners of the glabella, and merge into the preglabellar band—a depressed diverticulum in the floor of the preglabellar furrow. Caeca apparently pass forwards from this band near the anterolateral corners of the glabella, and pits lying in the anterior cranidial marginal furrow indicate the presence of others passing from the preocular areas into the anterior cranidial border. The anterior cranidial border is wide (sag.), occupying over 20% of the cranidial length (Lc) on the two measured specimens, and in profile slopes gently forwards. It is separated from the preocular areas and the parafrontal band by a well-defined anterior cranidial marginal furrow. Nothing is known of the posterolateral limbs.

Discussion. An interesting combination of cranidial characteristics poses classificatory problems for our material. Basically, this genus has the glabellar shape typical of Housiinae (Pterocephaliidae) combined with a preglabellar and preocular structure reminiscent of Mansuyiinae (Leiostegiidae). The posteriorly sited palpebral lobes tip the balance of diagnostic characteristics towards classification with Leiostegiidae.

The pear-shaped glabella, with only faint traces of glabellar furrows is found in three distinct groups of late Dresbachian and early Franconian trilobites. It is particularly characteristic of Housiinae (Pterocephaliidae) and is well expressed in *Housia* Walcott, *Prehousia* Palmer, and *Parahousia* Palmer (see Palmer 1954, 1960, 1965). These genera have variably long (sag.) preglabellar fields, but are united in having small (exsag.) palpebral lobes anteriorly situated and close to the axial furrows. Housiinae are typically distributed at the margins of the North American craton during the late Dresbachian. Contemporaneous, presently unsatisfactorily classified, relatives in Kazakhstan, referred by Ivshin (1956) to *Olentella*, *Kujandina*, and *Tatulaspis*, also have a pear-shaped glabella and variable preglabellar field. They have small palpebral lobes which are not as far advanced as in Housiinae, and which are more widely spaced (tr.). The Spanish specimens resemble *Tatulaspis* Ivshin most because it has the shortest (sag.) preglabellar field (see Ivshin 1956, pl. 9, figs. 1–4).

Also contemporaneous are various Pagodiinae (Leiostegiidae) which inhabited the fringes of the Siberian, North Chinese, and North American cratons. *Chuangia frequens* (Dames) has an appropriate glabella which extends to the anterior cranidial marginal furrow, but its anterior border, as in the majority of leiostegiids is reflected rather than depressed as in the Spanish specimens (see Schrank 1974, pl. 1, fig. 8). *Iranochuangia persica* (King) does have a depressed border, and indeed similar preglabellar structure altogether, but its glabella is more or less straight-sided, gently tapering forwards (see King 1937, pl. 2, fig. 4a). *Bernicella minuta* Frederickson (1949, pl. 68, figs. 14–16), from Oklahoma, is a more obvious pagodiine with a pear-shaped glabella. Species of *Chuangiopsis* Sivov (1955), an enigmatic southern Siberian genus of uncertain classificatory position, may also be related to the undetermined Spanish leiostegiid.

The structure of the preglabellar and preocular areas is reminiscent of younger leiostegiids assigned to the Subfamily Mansuyiinae (Shergold 1980), as are the posteriorly sited palpebral lobes (cf. *Peichiashania rectangularis* (Endo) *in* Endo and Resser 1937, pl. 68, fig. 21). Mansuyiinae such as *Peichiashania*, however, have a relatively long (sag.) concave preglabellar area, and reflected, rather than depressed, anterior cranidial border.

The Spanish leiostegiid probably represents a new generic taxon, but before this can be named it is necessary to confirm the extent of the palpebral lobes and the posterolateral limbs. Our current material is inadequate for this purpose.

<div align="center">

Family SHIRAKIELLIDAE Hupé, 1953
Genus LANGYASHANIA Lu and Zhu, 1980

</div>

Type species. Langyashania distincta Lu and Zhu (1980, p. 17, pl. 5, figs. 2–4; pl. 6, fig. 12?). Late Cambrian, middle Langyashan Formation, Chuxian–Quanjiao region, eastern Anhui Province, China; by original designation.

Other species. Langyashania transversa Lu and Zhu (1980, p. 17, pl. 5, figs. 5–8), locality and age as above. Some Late Cambrian species assigned to *Megagraulos* by Kobayashi (1962), e.g. *M. breviscapus* Kobayashi (1962, p. 66, pl. 2, fig. 1) from the *Eochuangia* Zone of South Korea, but not *M. medius* (op. cit., pl. 2, figs. 2–3, = ?*Maladioidella*) from the same locality.

Discussion. Shirakiellidae are late Cambrian agrauloid trilobites with anteriorly situated palpebral lobes, preglabellar fossulae, and truncatoconical glabella with effaced furrows. The family, comprising the genera *Shirakiella* Kobayashi, 1935, *Neoshirakiella* Sun and Xiang, 1980, and *Langyashania* Lu and Zhu, 1980, has a Changshanian and Fengshanian age in South Korea (Kobayashi 1935, 1962), south-western China (Sun and Xiang 1980), and eastern China (Lu and Zhu 1980). *Langyashania* differs from species of *Shirakiella*, as conceived by Kobayashi (1935, 1960)

<div align="center">

EXPLANATION OF PLATE 12

</div>

Figs. 1–3. *Langyashania felixi* sp. nov. 1, U1/2/24, holotype, internal mould of cranidium, length 12·5 mm; × 3. 2, U1/26, internal mould of cranidium, length 11·75 mm; × 3. 3, U1/2/24, lateral view of holotype, × 3.

Figs. 4–7. Leiostegiid? gen. et sp. undet. 4, U1/2/27, internal mould of cranidium, length 19 mm, showing trace of granulose prosopon, × 2. 5, U1/2/27, as above, latex replica, × 2. 6, U1/2/80, sagitally compressed internal cranidial mould, indicating convexity (sag.) and glabellar furrows, estimated length 18·5 mm; × 2. 7, U1/2/27, lateral view, × 2.

Figs. 8–11. Aphelaspidine gen. et sp. undet. 8, U1/2/15, internal mould of cranidium, length 9 mm; × 3·5. 9, U1/2/100A, latex replica of cranidial mould, × 5. 10, U1/2/95, internal mould of pygidium, length (L_p_1) 7·5 mm; × 4·5. 11, U1/2/96, internal mould of pygidium, length (L_{p_1}) 6 mm; × 4·5.

Figs. 12–13. Solenopleuracean? gen. et. sp. undet. aff. *Lajishanaspis* sp. 12, U1/4/1, internal mould of cranidial fragment, × 5. 13, U1/4/1, as above, lateral view, × 5.

Figs. 14–15. Pagodiine gen. et sp. undet., aff. *Pagodia* (*Wittekindtia*) sp. 14, C1/5/1, latex replica of cranidial internal mould, estimated length 8·5 mm; × 3. 15, C1/5/2, latex replica of pygidial internal mould, estimated length (L_{p_2}) 6 mm; × 3.

PLATE 12
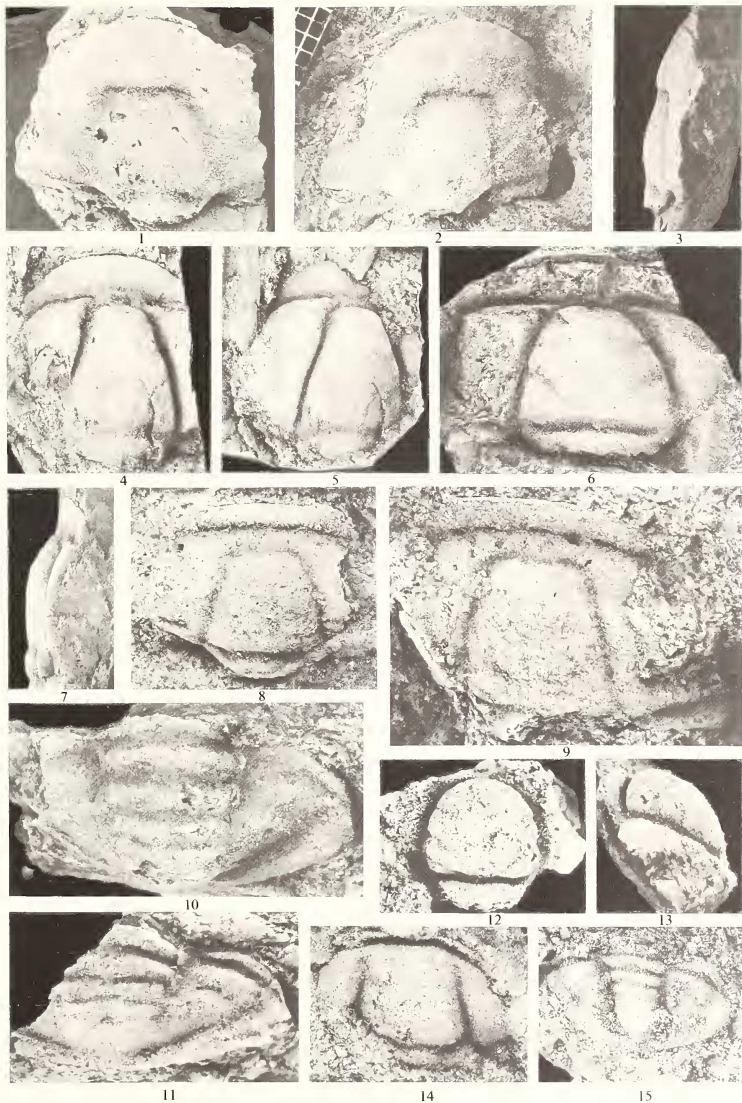
SHERGOLD, LIÑÁN and PALIACOS, Spanish Cambrian trilobites

non Lu *et al.* (1965), by having more widely spaced palpebral lobes and a proportionally wider (tr) preglabellar area. *Neoshirakiella*, not readily interpretable from its illustrations, appears to have an anteriorly more rounded glabella, and may also have palpebral lobes lying closer to the axial furrows.

The cranidia at hand are those of an agrauloid trilobite, having effaced glabellar and anterior cranidial marginal furrows, and thus a gently convex (sag.), composite preglabellar area, as in *Agraulos* Hawle and Corda, 1847, an early paradoxididan middle Cambrian genus from Europe and maritime eastern North America with which they have been previously identified. They are referred to *Langyashania* on the combined glabellar, palpebral, and preglabellar morphology, and degree of effacement of their dorsal furrows. There are no pygidia among the Spanish collections which resemble those assigned to *Langyashania* by Lu and Zhu (1980, pls. 5–6).

Langyashania felixi sp. nov.

Plate 12, figs. 1–3

1967   *Agraulos longicephalus* (Hicks); Colchen 1967, p. 1687 (listed).
1974   *Agraulos longicephalus* (Hicks); Colchen 1974, p. 179 (listed).

Name. This species is named for Dr. Félix Pérez-Lorente, University College of Logroño, in appreciation of his assistance in collecting this material.

Types. Holotype, cranidium, University of Zaragoza Palaeontological Collection U1/2/24; paratypes, same collection, N1/8/1a, N1/8/6, N1/8/10, U1/2/23, 25, 26, 72a–b, U1/3/1, 6, 9, 12b.

Material. This taxon is based on fourteen quantifiable cranidia, all internal or external moulds, ranging in length (Lc) between 5·25 and 12·50 mm.

Occurrence. Rio Najerilla section, horizon N1/8; Rio Urbión section, horizons U1/2, U1/3; from within member 1 of the Najerilla Formation.

Diagnosis. A transverse species of *Langyashania* with relatively small, wide spaced, anteriorly situated palpebral lobes, and comparatively flat dorso-ventral profile.

Description. Langyashania felixi has an anteriorly broadly rounded cranidium which is mostly effaced. It has low convexity (tr., sag.) when viewed both laterally and anteriorly. The glabella is subrectangular, anteriorly truncate, slightly tapering forwards, 43–57% of the cranidial length, 61–76% if the occipital ring is included. Glabellar furrows are effaced. Axial furrows are deeply incised only in front of the glabella, where a pair of shallow pits is situated near the anterolateral corners of the glabella. On some specimens, these cause indentations along the posterior edge of the preglabellar field. The occipital furrow is anteriorly bowed, and does not reach the axial furrows laterally, apparently defining a crescentic occipital ring. A pair of diverticula, issuing from the abaxial extremities of the occipital ring, merges into the postocular fixigenae, and the posterior cranidial margin appears to pass underneath the occipital ring. An occipital node is faintly discernible. The palpebral lobes are faintly defined, small (A : Gn 27–37%), sited anterior to the middle of the glabella (G), and distant from the axial furrows. The transverse width of the palpebral areas is approximately two-thirds that of the glabella opposite the mid-points of the palpebral lobes. Faint ocular ridges are present on some specimens. The preocular sections of the facial suture are not widely divergent, and meet in a wide arch sagitally. They enclose a preglabellar area, 24–42% of the cranidial length (sag.) which has a gentle anterior convexity (sag.). Preocular areas are not differentiated, but occasionally it is possible to observe a faint anterior cranidial marginal furrow dividing an anterior border from an equally wide (sag.) preglabellar field. The postocular facial sutures diverge appreciably and enclose triangular posterolateral limbs which bear mostly shallow posterior marginal furrows. The anterior edge of these furrows appears to be formed by the diverticula which originate from the occipital ring noted above.

Discussion. Langyashania felixi has lower dorso-ventral relief than other species assigned to this genus. It has wider spaced palpebral lobes than either *L. distincta* or *L. transversa* from Anhui. In this last characteristic it more closely resembles the cranidium referred by Kobayashi (1962, p. 66, pl. 2, fig. 1) to *Megagraulos breviscapus* Kobayashi from the *Eochuangia* Zone of South Korea. This species differs from the type species of *Megagraulos, M. coreanicus* Kobayashi, 1935, which

has more posteriorly situated palpebral lobes, and a non-interrupted transverse occipital furrow. *M. breviscapus* appears to have a narrower preglabellar area than *L. felixi*. It may represent another species of *Langyashania*.

Colchen (1967) has drawn attention to specimens of *Agraulos longicephalus* (Hicks), illustrated by Sdzuy (1961, pl. 23, figs. 7–17), which are associated with middle Cambrian genera such as *Paradoxides*, *Solenopleuropsis*, and *Pardailhania inter alia* in the Murero-Schichten of the Ateca district (Aragon) and Bres (Asturia), and concluded that these are no different from the form occurring on the Rio Urbión section. Accordingly, Colchen (1967, 1974) referred to the presence of *Agraulos longicephalus* at the base of his lithological Unit XI (faunal horizons F1 and F2), i.e. at the base of the Najerilla Formation of this paper, on the hillside above the intersection of roads from Viniegra de Abajo and Ventrosa de Viniegra, about 0·75 km north of the former (text-fig. 1). Following Lotze (1961), he assigned this part of the sequence to the middle Cambrian. Since Colchen's horizon F3, with *Billingsella* cf. *linguaeformis* Nikitin (Colchen and Havliček 1968), is the same as our locality U1/3 on this section, we feel that the horizon with *Agraulos* must probably be the same as our locality U1/2. The faunas described here from U1/2 and U1/3 are essentially the same, so that it seems that *A. longicephalus* (Hicks) *sensu* Colchen refers to *Langyashania felixi* sp. nov. Although similar, *Agraulos* and *Langyashania* can be distinguished. The latter has a more anteriorly truncate glabella with more totally effaced furrows; occipital furrow not reaching the axial furrows laterally and defining a crescentic rather than transversely annulate occipital ring; a pair of shallow pits in the preglabellar furrow at the anterolateral corners of the glabella; and preocular areas which are confluent with the preglabellar area.

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